Non-prompt $J/\psi$ measurement with the PHENIX VTX detector at RHIC

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Introduction

Heavy quark (bottom and charm) is a clean probe to study the property of QGP.
- Bottom and charm separation is imperative to understand heavy quark suppression in QGP.
  - New result of separated bottom and charm yield
  - D. McGlinchey (talk 9/28 space 2B, poster)
  - H. Asano (poster)

Non-prompt $J/\psi$ as a probe
- $B \rightarrow J/\psi + X \rightarrow e^+ + e^-$
- This is a direct measurement of $B$ production.
  - Bottom & charm separation is not necessary, which introduces additional systematic uncertainty.
  - It is challenging to extract the signal
  - Branching ratio ($B \rightarrow J/\psi$) is small (~1%)
  - Main background is prompt $J/\psi$ that comes from the collision vertex

Silicon Vertex Tracker (VTX)

- Structure : 4 Si layers (2 pixel & 2 stripixel)
- Wide acceptance: $|\phi| \sim 2\pi, |y|<1.2$
- Capabilities:
  - Precise tracking around collision vertex
  - Collision vertex determination
  - DCA resolution is ~60 $\mu$m (pT>4GeV/c) for electron measurement

Data analysis

Analysis method
1. $J/\psi \rightarrow e^+e^-$
   - $e^+e^-$ pairs are measured by the central arm + VTX
2. 2nd vertex reconstruction
   - The position of closest approach for $e^+e^-$ pairs in 2D plane (X-Y).

Improve the $J/\psi$ signals
- Conversion veto cut
  - remove electrons from Dalitz decays & conversions for reduction of the combinatorial BG.
- $Z$-Distance of $e^+e^-$ at 2nd vertex position
  - $Z$-distance should be zero for true pairs but non-zero for fake pairs

Summary & Outlook

- Non-prompt $J/\psi$ extraction is feasible based on simulation
- Data analysis is in progress for both p+p and Au+Au 200GeV
  - VTX improves the $J/\psi$ measurement and reduces combinatorial BG.
  - Single electron DCA can enrich the non-prompt $J/\psi$ signal
  - Large amount of p+p and Au+Au data was recorded in run2014 & 2015
- Statistics is 10 times larger than run11 Au+Au
  - 10 B min. bias Au+Au collisions
  - VTX performance was improved

Non-prompt $J/\psi$ extraction

Pseudo proper time ($x$) of $B$ using the $J/\psi$

$$x = \frac{Lxy \cdot M_{J/\psi}}{p_T(J/\psi)} - c t(B)$$

Secondary $J/\psi \rightarrow e^+e^-$

Collision Vertex

Secondary Vertex

Pseudo proper time distribution in simulation (PYTHIA + GEANT)

Non-prompt $J/\psi \rightarrow e^+e^-$

Prompt $J/\psi \rightarrow e^+e^-$

Non-prompt $J/\psi$ can be extracted using shape difference of pseudo proper time

Single electron DCA can improve non-prompt $J/\psi$

Expected yield of non-prompt $J/\psi$

- Number of $J/\psi$ is 10000 @ 10 B minimum bias data in Au+Au 200GeV
- $J/\psi$ yield in p+p 200GeV
  - Non-prompt $J/\psi$: $\sigma_{B\rightarrow J/\psi}e^+e^- = 1.2 nb$ (PRL.103.082002 PHENIX)
  - Prompt $J/\psi$: $\sigma_{J/\psi}e^+e^- = 45 nb$ (PRL. 98, 232002 PHENIX)
- Production ratio: 2.6% in p+p, 5.2% in Au+Au
- 50% of suppression factor is used for Prompt $J/\psi$ yield in Au+Au
- The expected non-prompt $J/\psi$ is 100~200 in Au+Au 200GeV